

The SETI Program Plan and Instrument Development Status

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The SETI (Search for Extraterrestrial Intelligence) Program is a NASA Supporting Research and Technology Program with primary thrust to search the microwave region of the spectrum for signals of extraterrestrial intelligent origin. During the next several years, the foremost SETI Program goal is the development of a SETI Breadboard Instrument. This article describes the SETI Program Plan and current SETI Breadboard Instrument development activities.

I. Introduction

Serious scientific concern with the possibility of detecting extraterrestrial intelligence dates back at least to 1959, when Cocconi and Morrison published (Ref. 1) a paper entitled "Search for Interstellar Communications." Additional scientific papers on this subject were published during the 1960s. In the 1970s, more intensive and formal studies of the subject were conducted. Notable during this time frame were study efforts which are documented in "Project Cyclops: A Design Study of a System for Detection of Extraterrestrial Life" (Ref. 2) and "The Search for Extraterrestrial Intelligence (SETI)" (Ref. 3). During the late 1970s, intensive effort was undertaken at the Jet Propulsion Laboratory (JPL) and Ames Research Center (ARC) to obtain the initiation of a formal SETI (Search for Extraterrestrial Intelligence) Program under NASA sponsorship. Starting in fiscal (FY) 1980, such a program has come into existence. The NASA

SETI Program is a Supporting Research and Technology (SR&T) effort with primary thrust to search the microwave region of the spectrum for signals of extraterrestrial intelligent origin. The SETI Program is managed by the Life Sciences Division of NASA's Office of Space Sciences, and within the Life Sciences Division, is an element of the Life in the Universe Program.

Initially, the foremost goal of the SETI SR&T Program is the development of a SETI Breadboard Instrument. Beyond the SR&T effort, the goal of the SETI Program will be the exploration of a well-defined volume of multidimensional microwave search space using large existing radio telescopes and a new technologically sophisticated data acquisition and analysis system (Berman, Ref. 4, Gulkis et al., Ref. 5). The approach of this SETI search includes two major components — a "target survey," which will observe at high sensitivity

all attractive star candidates within 25 parsecs of the sun, and a "sky survey," which will observe the entire celestial sphere at a somewhat lower sensitivity. The sky survey will cover all frequencies between 1 and 10 GHz, while the target survey will cover the frequency range 1 to 3 GHz.

II. The SETI SR&T Program

The SETI SR&T Program mode is expected to operate for approximately 5 years. During this time period, the specific goals of the SETI SR&T Program are:

- (1) Develop a fully functional SETI Breadboard Instrument.
- (2) Evaluate the SETI Breadboard Instrument field experience to determine the most cost-effective method to implement a Microwave Observing Program (MOP).
- (3) Carry out limited but significant SETI observations.

The SETI Breadboard Instrument will be operated primarily with radio telescopes at DSS 13 and Arecibo, Puerto Rico, with some considerably smaller usage on the DSN 64- and/or 34-m radio telescopes. The SETI Breadboard Instrument will initially be 74K channels single polarization, and during the SR&T Program will be upgraded in four phases to 500K channels dual polarization. Although only a single breadboard instrument is being developed, it will, during the various phases of development, contain functional capabilities pertaining to both sky survey and target survey modes. In particular, Phase III will emphasize the sky survey mode, while Phase IV will support the target survey mode.

High-level functional requirements for the SETI Breadboard Instrument during the planned 4 phases of development during the SR&T Program are as follows:

- (1) Phase I Breadboard Instrument
 - (a) 74-kHz bandwidth/1-Hz resolution
 - (b) 1024-Hz, 32-Hz, 1-Hz outputs
 - (c) Single polarization
- (2) Phase II Breadboard Instrument
 - (a) 74-kHz bandwidth/1-Hz resolution
 - (b) 1024-Hz, 32-Hz, 1-Hz outputs
 - (c) Dual polarization
- (3) Phase III Breadboard Instrument
 - (a) 4-MHz bandwidth/32-Hz resolution
 - (b) 74-kHz/1-Hz resolution

(c) 1024-Hz, 32-Hz, 1-Hz outputs

(d) Dual polarization

(4) Phase IV Breadboard Instrument

(a) 4-MHz bandwidth/32-Hz resolution

(b) 500-kHz bandwidth/1-Hz resolution

(c) 1024-Hz, 32-Hz, 1-Hz outputs

(d) Dual polarization

III. SETI Breadboard Instrument Development

A. SETI Breadboard Instrument – System Development

The goals of the SETI Breadboard Instrument system development are described as follows:

- (1) The rapid development of a SETI Breadboard Instrument and subsequent integration with Deep Space Station equipment, thus allowing the timely acquisition of SETI field experience in an operational environment.
- (2) The carrying out of limited but significant SETI observations.

In seeking to accomplish the above goals, the SETI Breadboard Instrument system will be implemented according to the following precepts:

- (1) Utilization to the highest degree of existing Deep Space Station equipment.
- (2) Allocation of the majority of SETI resources to the development of the Multichannel Spectrum Analyzer and Signal Processor – the SETI areas which require development of new technology.

Figure 1 presents a simplified block diagram of the SETI Breadboard Instrument system at DSS 13. As is seen, the front end, including antenna mechanical, antenna microwave, Block III receiver, and noise adding radiometer, are existing DSS 13 equipment. The portion of the SETI Breadboard Instrument system (i.e., the "SETI Breadboard Instrument") currently under development includes the SETI downconverter, the analog-to-digital converter (ADC), the Multichannel Spectrum Analyzer (MCSA), and the SETI Signal Processor (initially the "SETI Computer").

The development of the SETI signal processing functions will be started by using the breadboard equipment to generate and store real-time data. Non-real-time test algorithms will

evaluate this data and be utilized to determine the most efficient approach to the signal processing tasks. Once a signal processing task (e.g., developing a baseline for the data that removes instrument gain variation, applying threshold tests to the data, dedrifting CW signals, etc.) has been successfully tested, a hardware version will be developed. As the Signal Processor's special hardware is developed, the SETI Computer will move toward real-time data analysis, instead of the "snapshotting" of data and subsequent processing.

The phased SETI Breadboard Instrument development will provide the total experience necessary to design a technically capable and cost-effective operational SETI Instrument. In particular, new advances anticipated in the area of very large scale integration (VLSI) can be expected to play a significant role in the operational SETI Instrument.

B. SETI Breadboard Instrument Phased Development

1. **Phase I.** The Phase I SETI Breadboard Instrument will have a 74-kHz passband, single polarization, with 1024-, 32-, and 1-Hz outputs. Signal identification will be accomplished via software using the SETI Computer. This breadboard configuration represents a narrow profile in the frequency domain of either a sky survey or target survey type instrument. Figure 2 presents a functional block diagram of the Phase I configuration.

2. **Phase II.** Phase II augments the SETI Breadboard Instrument in two significant ways, as follows:

- (a) Baseline and threshold algorithms will be implemented in high-speed, special-purpose hardware that is capable of operating at the data rates envisioned for the fully operational SETI Instrument.
- (b) A second channel will be added to allow dual polarization signals for usage in the evaluation of SETI identification algorithms.

Figure 3 presents a functional block diagram for the Phase II SETI Breadboard Instrument.

3. **Phase III.** In Phase III, the 1024- and 32-Hz resolution outputs are increased from 74 kHz to 4 MHz, thus allowing the first significant sky survey observations. In addition, the Signal Processor development of Phase II is continued by the addition of a pulse detector module. Figure 4 presents the functional block diagram of the Phase III SETI Breadboard Instrument.

4. **Phase IV.** Phase IV completes the SETI Breadboard Instrument by adding a module to dedrift CW signals and expanding the passband capability of the 1-Hz output resolution from 74 kHz to 500 kHz, thereby providing the ability to make the first significant target survey observations, as well as performing all signal identification in special-purpose signal processing hardware. Figure 5 presents a functional block diagram of the Phase IV SETI Breadboard Instrument.

C. SETI Breadboard Instrument Development Status

The SETI Breadboard Instrument development was begun in mid-1980, and has been previously reported on by Crow (Ref. 6). Delivery of the completed SETI Phase I Breadboard Instrument is scheduled for mid-1982. The SETI-peculiar equipment that is currently under development is the SETI downconverter, analog-to-digital converter (ADC), Multichannel Spectrum Analyzer (MCSA) and the SETI Computer.

The SETI Computer (a PDP 11/44) has been received and is currently being installed. Remote operating terminals will be provided to allow the SETI Science Team to utilize the SETI Computer from remote locations both at JPL and ARC. The SETI downconverter and analog-to-digital converter have been fabricated and are currently undergoing subsystem testing. The Multichannel Spectrum Analyzer development is currently in the module fabrication phase and is scheduled for shipment to JPL in early 1982.

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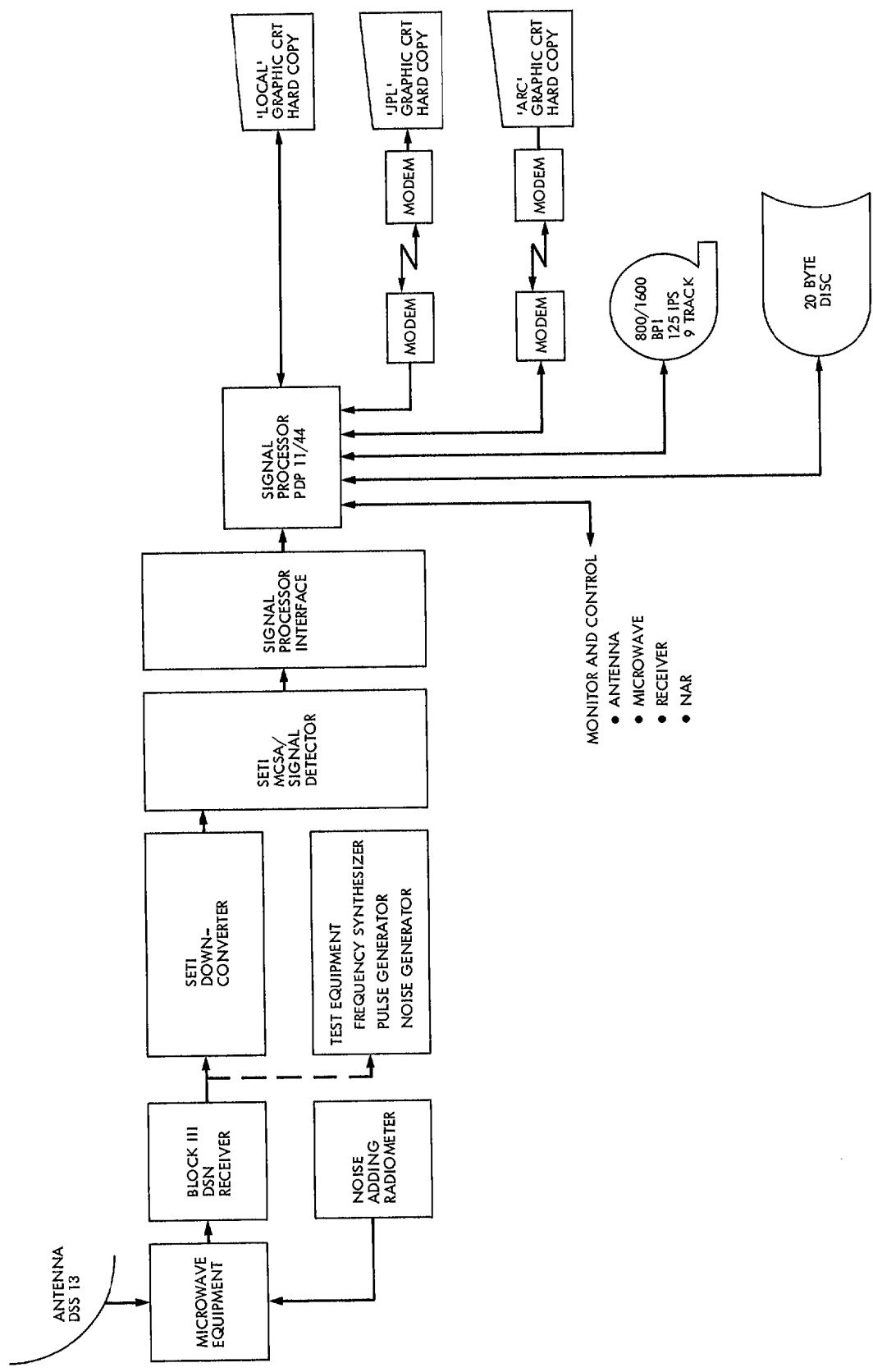
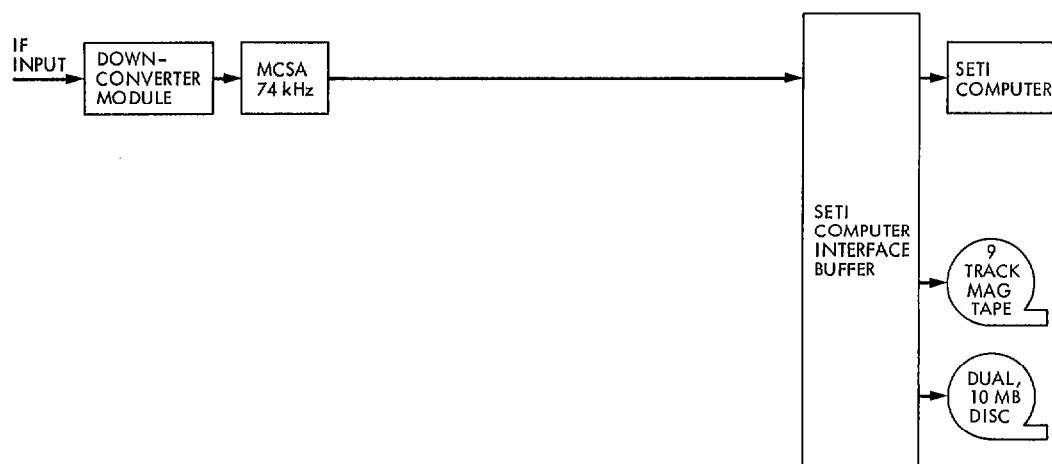
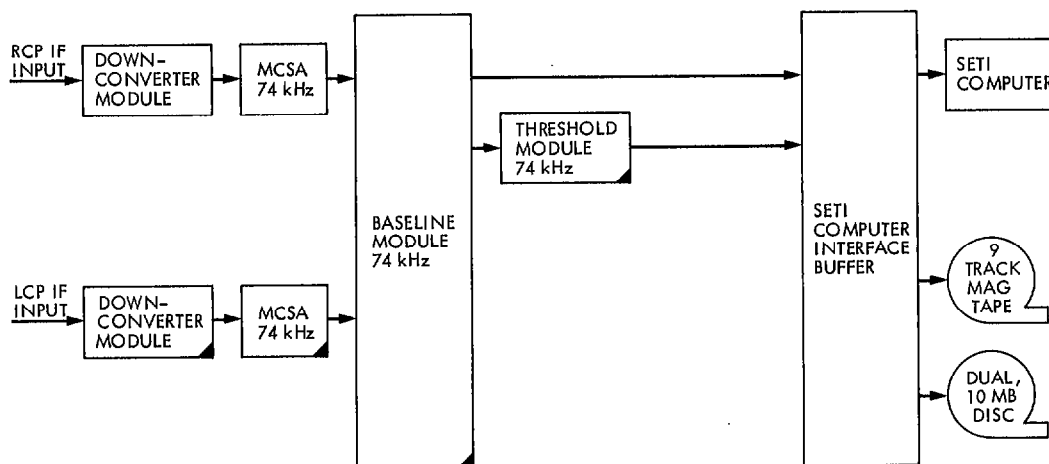


Fig. 1. SETI Breadboard Instrument system functional block diagram



DATA TYPE	BW	RESOLUTION
POWER	74 kHz	74 kHz, 1024 Hz, 32 Hz, 1 Hz
COMPLEX VOLTAGE	74 kHz	1024 Hz, 32 Hz, 1 Hz
ACCUMULATION POWER	74 kHz	1024 Hz, 32 Hz, 1 Hz

Fig. 2. Phase I SETI Breadboard Instrument functional block diagram



DATA TYPE	BW	RESOLUTION
POWER	74 kHz	74 kHz, 1024 Hz, 32 Hz, 1 Hz
COMPLEX VOLTAGE	74 kHz	1024 Hz, 32 Hz, 1 Hz
ACCUMULATION POWER	74 kHz	1024 Hz, 32 Hz, 1 Hz

▲ = PHASE II UPGRADE

Fig. 3. Phase II SETI Breadboard Instrument functional block diagram

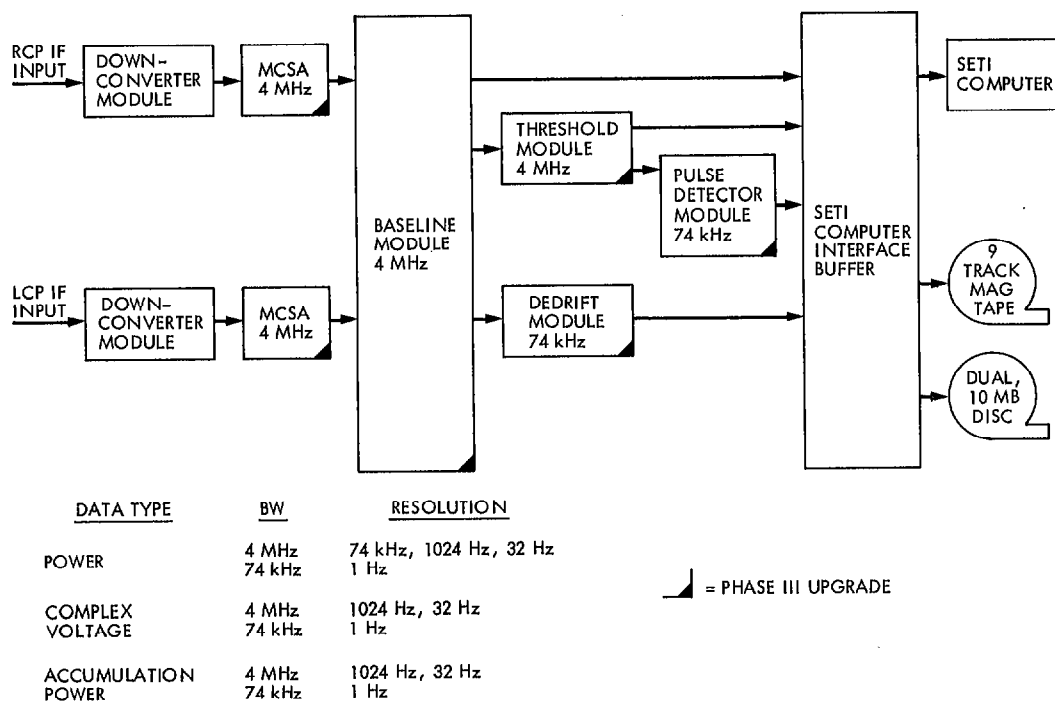


Fig. 4. Phase III SETI Breadboard Instrument functional block diagram

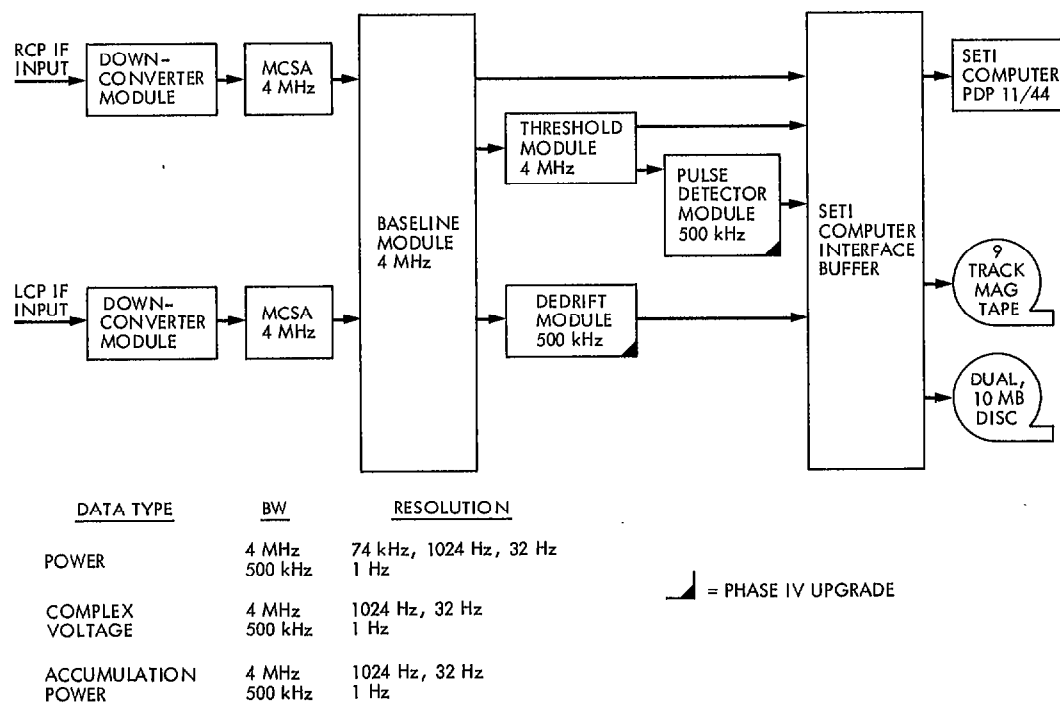


Fig. 5. Phase IV SETI Breadboard Instrument functional block diagram